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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/403,220	12/20/1999	RON LEVKOVITZ	154/01214	6991

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EXAMINER	
MILLER, MARTIN E	
ART UNIT	PAPER NUMBER
2623	

DATE MAILED: 03/11/2003

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)	
	09/403,220	LEVKOVITZ ET AL.	
	Examiner	Art Unit	
	Martin Miller	2623	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☐ Responsive to communication(s) filed on _____ .

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) 1-35 is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) 1-35 is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☒ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on 20 December 1999 is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

11)☐ The proposed drawing correction filed on _____ is: a)☐ approved b)☐ disapproved by the Examiner.

If approved, corrected drawings are required in reply to this Office action.

12)☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

13)☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☒ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____ .

3.☒ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).

a) ☐ The translation of the foreign language provisional application has been received.

15)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO-1449) Paper No(s) 6 & 7 .
4) ☐ Interview Summary (PTO-413) Paper No(s). _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: .

DETAILED ACTION

Information Disclosure Statement

1. The examiner has considered the IDS filed April 03, 2000 and the November 01, 2000 and an initialed copy of each is included with this office action.

Specification

2. This application does not contain an abstract of the disclosure as required by 37 CFR 1.72(b). An abstract on a separate sheet is required.

Applicant is reminded of the proper language and format for an abstract of the disclosure.

The abstract should be in narrative form and generally limited to a single paragraph on a separate sheet within the range of 50 to 150 words. It is important that the abstract not exceed 150 words in length since the space provided for the abstract on the computer tape used by the printer is limited. The form and legal phraseology often used in patent claims, such as "means" and "said," should be avoided. The abstract should describe the disclosure sufficiently to assist readers in deciding whether there is a need for consulting the full patent text for details.

The language should be clear and concise and should not repeat information given in the title. It should avoid using phrases which can be implied, such as, "The disclosure concerns," "The disclosure defined by this invention," "The disclosure describes," etc.

Claim Objections

3. Claim 14 has a grammatically difficult construction where the limitation states, "successive iterations iterative method". The applicant desires to keep the "iterative method" terminology the examiner suggests -- successive iterations of the iterative EM method-- or some other clarification.

Claim Rejections - 35 USC § 112

4. The following is a quotation of the second paragraph of 35 U.S.C. 112:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

5. Claims 22-35 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

Claim 22 recites the limitation "iteratively reconstructing a three-dimensional image from the unbinned individual radiation events", however, there is no usage of the word "unbinned" in the disclosure or used in the US patent data base with respect to tomography. The examiner can only glean the meaning of "unbinned" from what is not said in the specification. The examiner's understanding is that several individual radiation events are usually grouped together in "bins" in order to ease the computational burden, when reconstructing an image. However, the applicant seems to intend to use the all of the individual radiation events to reconstruct the image. So the instant claim does not suggest that some of the radiation events are binned and then those that are unbinned are used to recreate the entire image, but suggests that none of the individual radiation events are binned. Therefore, the claim is vague and indefinite.

Claims 31 and 33 also recite a similar limitation regarding "unbinned events", which results in the same vagueness and indefiniteness.

Accordingly, claims 23-30 are also rejected due to its dependence upon claim 22, claim 32 for its dependence upon claim 31, and claims 34 and 35 for their dependence upon claim 31.

Note that the examiner is interpreting "unbinned" to mean that none of the radiation events are initially binned and that the radiation events are processed individually.

6. Claim 22 recites the limitation "the unbinned individual radiation events" in line 4 of the claim. There is insufficient antecedent basis for this limitation in the claim. There is no claim of binning individual radiation events or leaving any radiation events unbinned.

Claim Rejections - 35 USC § 102

7. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

8. Claims 1, 3-9 are rejected under 35 U.S.C. 102(b) as being clearly anticipated by Hasegawa et al. (hereinafter Hasegawa), US 5376795.

As per claim 1, Hasegawa teaches:

acquiring data (as represented by the pixel data of Hasegawa, or col. 9, ll. 8-12) on the geometric coordinates of detection of individual (pixels inherently have geometric coordinate values) radiation events ("photons in a unit of time", col. 9, l. 3, or col. 13, ll. 13-21);

Separately distributing a weight (col. 13, ll. 29-30) of each of the individual radiation events along a line of flight (linear, col. 11, l. 33 and col. 13, l. 29) associated with the event determined from the acquired data (count, col. 9, ll. 9-11, 17-19,) on the geometric coordinates of detection of the individual event (for "50 ns", col. 9, l. 25); and

iteratively reconstructing the image based on the distributed weights (col. 10, ll. 44-49, col. 13, ll. 53-55).

As per claim 3, Hasegawa teaches:

wherein the line of flight of an event is determined based on the position at which the event was detected on a detector and the acceptance direction of a collimator through which the detector receives radiation associated with the events (figures 1A and 1B, col. 10, ll. 51-53).

As per claim 4, Hasegawa teaches:

Wherein the line of light of an event is determined by the position on a detector on which the event is detected and the location of the source of radiation associated with the event (figures 1A and 1B).

As per claim 5, Hasegawa teaches:

wherein the line of flight associated with an event is determined by detection of two coincident photons (col. 8, l. 66-col. 9, l. 3).

As per claim 6, Hasegawa teaches:

wherein iteratively reconstruction the image comprises applying an iterative expectation maximization (EM) method on the data in sub-sets (col. 4, ll. 25-29).

As per claim 7, Hasegawa teaches:

wherein the individual events form the separate subsets ("image subsets can be generated concurrently with acquisition of projection data", last sentence of Abstract).

As per claim 8, Hasegawa teaches:

wherein the sub-sets are formed based on the time of acquisition of events (last sentence of Abstract and col. 9, l. 25). The event is recorded for 50 ns.

As per claim 9, Hasegawa teaches:

wherein the sub-sets are formed from unrelated events (col. 9, ll. 8-41).

Claim Rejections - 35 USC § 103

9. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

10. This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

11. Claims 2, 10-35 are rejected under 35 U.S.C. 103(a) as being unpatentable over Hasegawa and Hudson et al. (hereinafter Hudson), "Accelerated Image Reconstruction Using Ordered Subsets of Projection Data", IEEE Transactions on Medical Imaging, vol. 13, no. 4, December 1994.

As per claim 2, Hasegawa teaches:

wherein the weights are distributed in voxels (col. 10, l. 41) along the line of flight (ray-sums (col. 10, ll. 52) and wherein the weight (fractional weight, col. 10, l. 47) of a particular event. However, Hasegawa does not specifically teach that such weights are distributed based on the probability that an event occurred in particular voxels. But Hudson teaches:

is distributed based on the probability that an event occurred in particular voxels. (p. 602, col. 1, in the paragraph continued from p. 601).

Therefore, it would have been obvious to one of ordinary skill in the art to utilize the weighting system of Hudson as an equivalent weighting system in the system of Hasegawa in order to take advantage of the full features of Hudson's ordered subset approach.

As per claim 10, Hasegawa teaches:

acquiring data on the geometric coordinates of detection of individual radiation events (col. 13, ll. 13-21);

applying an iterative expectation maximization (EM) method (col. 4, ll. 25-37) on the data in sub-sets (last sentence of Abstract). However, Hasegawa does not teach the following limitation:

which are formed based on the time of acquisition of the data on the geometric coodiantes of detection of the events.

But Hudson does teach such a limitation at p. 601, col. 2, last paragraph that continues on to p. 602. Hudson teaches that the photon counts are indexed by time and that the weights represent a probability that a pixel from an emission is recorded at certain time.

It would have been obvious to one of ordinary skill in the art to use the ordered subset image reconstruction algorithms of Hudson as the iterative reconstruction procedure of so that the images can be reconstructed using less iteration due to an acceleration of the convergence of the image data.

NOTE: The examiner is differentiating the "acquisition of the data" above from the "acquisition of events" in claim 8 because "acquisition of events" implies to the examiner that data is determined at certain times over the duration of the imaging process, while an event is a discrete occurrence that takes 50 ns and then the second event is recorded. If the two phrases have the same meaning, the examiner would appreciate an explanation of the applicant's interpretation of the two different phrases as having the same meaning.

Claims 22, 31 and 33 recite substantially the same limitations as claim 10 above and analogous remarks apply. Claims 31 and 33 further recite a limitation that the sensors are

"spatially continuous area detectors" and "substantially planar area detectors" respectively, which is taught by Hasegawa in figures 1A-1D, elements 12, 13 or 14.

As per claim 11, Hudson teaches:

wherein the subsets consist of data having less than a 180 degree view angle (120 degrees, p. 602, col. 2, Sect. III, first paragraph).

As per claim 12, Hasegawa teaches:

wherein iterations of the EM Method are performed prior to the acquisition of data having a 180 degree angle of view (initial image estimate is prior to any data acquisition having an 180 degree view angle, col. 4, ll. 48-52).

As per claim 13, Hudson teaches:

wherein iterations are commenced on receipt of the first detection event (p. 602, col. 1, second paragraph, the initial state is a uniform prespecified starting image).

As per claim 14, Hudson teaches:

displaying an evolving image based on successive iterations iterative method on a display (p. 603, col. 1, under *Cumulative subsets* heading). Under the *Cumulative subsets* heading, Hudson teaches that data is combined to form a current restoration, it would have been obvious to one of ordinary skill in the art to display the current restoration to allow the user to see that the system is operating properly and to see the development of the image data as the algorithm progresses.

As per claim 16, Hasegawa teaches:

wherein intermediate images are filtered with a smoothing filter between iterations of the EM method (col. 8, ll. 29-33).

As per claim 17, Hasegawa teaches:

wherein intermediate images are filtered with a noise reducing filter between iterations of the EM method (col. 8, ll. 29-33).

As per claim 18, Hudson teaches:

wherein data is reused in subsequent iterations of the EM algorithm (p. 601, col. 2, last full paragraph).

As per claim 19, Hasegawa teaches:

wherein the images are three dimensional images (col. 6, ll. 23-35, voxels are obviously a 3 dimensional data representation, col. 10, ll. 35-49).

As per claim 20, Hasegawa teaches:

wherein the iterative method comprises reconstructing the events without forming two dimensional data sets (col. 10, ll. 35-49, which teaches voxels, which indicates a three-dimensional data set and col. 14, ll. 11-13 to correct "partial-volume effects").

As per claim 21, Hasegawa teaches:

wherein the iterative method comprises reconstructing from the events without forming sinograms for slices of the three dimensional data (slices are not used in the reconstruction of the images, col. 10. l. 35-49).

As per claim 23, Hasegawa teaches:

wherein reconstructing the image comprises utilizing an expectation maximization (EM) method acting on individual unbinned events (col. 4, ll. 25-38).

As per claim 24, Hasegawa teaches:

wherein the radiation events are nuclear emission events (col. 1, ll. 40-50, col. 2, ll. 11-13, col. 8, ll. 7-10) and the images are emission tomography images (col. 8, ll. 4-8, col. 9, ll. 8-25).

As per claim 25, Hasegawa teaches:

wherein the radiation events are positron decay events (col. 1, ll. 60-63 or Hudson, p. 602, col. 2, section III, second paragraph) and wherein the images are PET images (col. 4, ll. 45-46, col. 5, ll. 43-45, col. 8, ll. 7-10, col. 9, ll. 4-12 or Hudson, p. 602, col. 2, section III, second paragraph).

As per claim 26, Hasegawa teaches:

Wherein the radiation events are represented by photons which have passed through a subject (col. 9, ll. 8-12) and wherein the images are transmission (col. 6, ll. 3-8).

As per claim 27, Hasegawa teaches:

wherein the radiation events are nuclear (radionuclide, col. 5, ll. 43-45) disintegrations and wherein the images are nuclear transmission tomographic images (col. 6, ll. 3-8).

As per claim 28, Hasegawa teaches:

wherein the radiation events are X-rays (col. 5, l. 44) and wherein the images are X-ray CT images (col. 3, ll. 50-67, col. 4, ll. 5-9, col. 6, ll. 3-8, col. 8, l. 66-col. 9, l. 4).

As per claim 29, Hasegawa teaches:

wherein the line of flight associated with the radiation events form a fan beam (clearly from Hasegawa's figure 2, the line of flight of the photons will be in the form of a fan beam also, col. 7, ll. 28-30).

As per claim 30, Hasegawa teaches:

wherein the line of flight associated with the radiation events form a cone beam (col. 7, ll. 28-30).

As per claim 32, Hasegawa teaches:

wherein the spatially continuous detectors are substantially planar detectors (figure 1A, element 12).

As per claim 34, Hasegawa teaches:

wherein the plurality of detectors consists of two such detectors (figure 1A, element 12, transmission & radionuclide emission detector).

As per claim 35, Hasegawa teaches:

wherein the images are three dimensional images (col. 6, ll. 23-35, voxels are obviously 3 dimensional, col. 10, ll. 35-49).

12. Claim 15 is rejected under 35 U.S.C. 103(a) as being unpatentable over Hasegawa and Hudson as applied to claim 10 above, and further in view of US 5600574.

As per claim 15, neither Hasegawa nor Hudson specifically teach terminating a study. However, Reitan teaches:

determining if a study should be terminated based on the image quality of an image after an iteration (col. 25, ll. 44-49).

It would have been obvious to one of ordinary skill in the art to us the automatic image quality process of Reitan to automatically terminate the image reconstruction process of Hasegawa and Hudson when the image quality does not meet minimum quality standards thereby, reducing the amount of time and computational cost that may be wasted by reconstructing unusable images.

Conclusion

13. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure. The following U.S. patent(s) refer(s) to medical imaging: Roth, 4497024 and DiFilippo et al., 5793045 and 5969358.

The following articles refer to expectation maximization used in image reconstruction:

Manglos et al., "Attenuation Compensation of cone beam SPECT images using maximum likelihood reconstruction", IEEE Transactions in Medical Imaging, March 1991; Green, "Bayesian reconstruction from emission tomography data using a modified EM algorithm", IEEE Transactions in Medical Imaging, March 1990; and Pretorius et al., "Absolute Radionuclide Concentration Measurement using Maximum-Likelihood Expectation-Maximization Iterative Reconstruction, Attenuation, and Scatter Correction", IEEE Transactions in Nuclear Science, February 1996.

14. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Martin Miller whose telephone number is (703) 306-9134. The examiner can normally be reached on Monday-Friday, 9-5. If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Amelia Au can be reached on (703) 308-6604. The fax phone numbers for the organization where this application or proceeding is assigned are (703) 872-9314 for regular communications and (703) 872-9314 for After Final communications. Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is (703) 305-3900.

mem
February 28, 2003

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